

Use of FAMACHA system to evaluate gastrointestinal nematode resistance/resilience in offspring of stud rams

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Abstract

High levels of anthelmintic resistance in gastrointestinal nematodes (GIN) of small ruminants have created the need for animals with greater resistance to these parasites. The objective of this experiment was to evaluate the effectiveness of the FAMACHA system in identification of parasite resilient/resistant offspring, and thus identification of stud rams with greater resilience/resistance. Katahdin ewes bred in separate groups to two sires to lamb in spring (2004, 2005: Ram A and Ram B; 2006, 2007: Ram C and Ram D) at the USDA, Agricultural Research Station in Booneville, Arkansas produced 20–40 offspring/sire each year. Ewes and lambs grazed mixed grass (predominantly bermudagrass and ryegrass) pastures and were supplemented with corn/soybean meal between 30 days pre- and 60 days post-lambing (ewes) and starting 45 days of age until weaning (lambs; 95.0 ± 0.6 days of age). Blood samples and feces were collected from the lambs to determine blood packed cell volume (PCV) and fecal egg counts (FEC) and FAMACHA scores were determined at 90, 120, and 150 days of age. Lambs were dewormed if anemic (PCV < 19% or FAMACHA score > 2) and data removed within 30 days after deworming. Data were analyzed for the 2004/2005 and 2006/2007 groups using general linear models with year, sex of lamb, and sire nested within year as variables. Sire differences were detected ($P < 0.05$ or less) for PCV and FAMACHA at all time points, but not FEC. There tended ($P < 0.10$) to be sire differences for FEC at 90 and 120 days of age, but not at 150 days of age. Lambs sired by Ram D were dewormed less by 150 days of age than those sired by Ram C. The FAMACHA system can be used to identify superior sires for parasite resilience/resistance, thus increasing flock resilience, and perhaps resistance.

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Keywords: FAMACHA; Gastrointestinal nematode management; *Haemonchus contortus*; Katahdin; Lambs

1. Introduction

Over-reliance on chemical dewormers in the past led to the development of anthelmintic resistant gastrointestinal nematodes (GIN; Mortensen et al., 2003; Kaplan, 2004). There is a growing interest by producers

and consumers in the production of meat animals with minimal chemical input to reduce chemical residues in the meat and to increase the sustainability of livestock production (Green and Kremen, 2003). The Katahdin breed of sheep, which was developed in the northeastern U.S., has adapted well to the southern climate as well as other regions of the continent (Wildeus, 1997; Burke and Miller, 2002). However, the growing lamb remains susceptible to GIN infection (Burke and Miller, 2004). Selection of superior sires with identified resistance should be possible because heritability of parasite

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resistance, measured by fecal egg counts (FEC) or blood packed cell volume (PCV), is moderate (Piper, 1987; Woolaston and Baker, 1996; Raadsma et al., 1997; Bouix et al., 1998; Bisset et al., 2001; Miller et al., 2006).

The FAMACHA[®] system was validated to manage *H. contortus*-infected small ruminants in the United States (Kaplan et al., 2004). This system was developed in South Africa for classifying animals into categories based upon level of anemia (Bath et al., 1996; Malan et al., 2001; Van Wyk and Bath, 2002; Vatta et al., 2001). Only animals determined to be anemic should be dewormed. In previous studies it was determined that the FAMACHA system was a useful tool for identifying anemic sheep and goats in the southern US and that use of dewormers could be vastly reduced (Kaplan et al., 2004; Burke et al., 2007). The FAMACHA system can be used to select replacement animals that are resistant and/or resilient to *H. contortus* through proper record keeping. Animals that require fewer deworming treatments should be retained, while those that require more frequent treatments should be culled or removed from the flock.

The objective of this study was to evaluate differences between PCV, FEC, and FAMACHA scores of offspring of different Katahdin sires and determine whether the FAMACHA system would be a useful tool in evaluation of parasite resilience/resistance of stud rams.

2. Materials and methods

All experimental procedures were reviewed and accepted by the Agricultural Research Service Animal Care and Use Committee in accordance with the NIH guide for the Care and Use of Laboratory Animals. Pain and stress to animals were minimized throughout the experimental period.

Katahdin ewes and rams from a mixed source were obtained in 1999 and 2000 and replacement ewes and rams have been raised at USDA, Agricultural Research Service, Dale Bumpers Small Farms Research Center in Booneville, AR (DBSFRC) since that time. In addition, rams were purchased off farm in 2003 and 2005. In 2004, ewes that were bred in two separate groups to Ram A (purchased) and Ram B (raised at DBSFRC) lambled between mid-April to May. The subsequent year, ewes exposed to the same rams lambled between mid-January to February. In 2006 and 2007 ewes were bred by Ram C (purchased from a producer) and Ram D (raised at DBSFRC) and lambled between mid-January to February in both years. These rams were selected for weaning weight and multiple offspring production

(based on production records) as Katahdins are known to be moderately resistant to GIN (Burke and Miller, 2002, 2004). Twenty to forty offspring/sire were produced each year (Table 1). Body weight of lambs was determined within 24 h after birth.

While grazing mixed grass pastures (predominantly bermudagrass or ryegrass), ewes were supplemented with up to 1 kg/ewe daily of corn/soybean meal (15% crude protein, dry matter basis) 30 days before lambing until 60 days post-lambing. Their offspring were creep fed a similar ration up to 500 g/head daily starting at approximately 45 days of age until weaning at 95.0 ± 0.6 days of age. At weaning lambs grazed mixed grass pastures (predominantly bermudagrass or tall fescue) at a stocking rate of 17 lambs/ha and in 2004 and 2005 were supplemented with 500 g/head daily of corn/soybean meal (no supplement in 2006 and 2007). Lambs were offered free choice trace mineralized salt (Land O'Lakes Sheep and Goat Mineral, Shoreview, MN) and water throughout.

Body weight and FAMACHA eye scores (2006 and 2007 only) were determined at approximately 60 (body weight only), 90, 120, and 150 days of age. Lambs are not handled before 60 days of age and do not typically show signs of parasitism until 90 or 120 days of age. At the latter three time points, feces were collected directly from the rectum to determine fecal egg count (FEC; modified McMaster technique with a sensitivity of 50 eggs/g; Whitlock, 1948) and blood from the jugular vein to determine blood packed cell volume (PCV).

More than 85% of larvae cultured from feces collected from lambs was identified as *Haemonchus contortus* (Burke and Miller, 2006). In 2004 and 2005, lambs were administered levamisole (Levasol, 8.0 mg/kg) if PCV declined below 19%. Efficacy of levamisole on this farm was 75% in 2005 (Burke and Miller, 2006). In 2006 and 2007, lambs were administered 0.5 g copper oxide wire particles (COWP; Copasure; Animax Veterinary Technology, UK) in a gelatin capsule (Burke

Table 1
Number of offspring for each ram sampled at 90, 120, or 150 days of age for each year

Ram no.	2004		2005		2006 ^a		2007	
	A	B	A	B	C	D	C	D
90 days	40	23	26	30	16	27	30	24
120 days	8	4	24	27	21	39	20	16
150 days	28	19	0	0	7	30	27	22

Data from lambs were removed if the lambs had been dewormed in the 30 days before the sampling date.

^a All lambs failed to be sampled for packed cell volume and FAMACHA at 90 days.

et al., 2004; Burke and Miller, 2006) if FAMACHA score was 3 or above (Burke et al., 2007). None were dewormed before 90 days of age. Rainfall between 60 and 150 days of age each year was recorded (Fig. 1).

Data were analyzed using the general linear models procedure of SAS (1996) using separate models for 2004, 2005 (Rams A and B) and 2006, 2007 (Rams C and D). The mathematical model used for PCV, FEC, FAMACHA scores, and body weight included year, gender of lamb, and sire nested within year. For body weight, number of lambs in litter was also included as an independent variable and birth order used as a continuous variable. FEC data were log transformed: $\ln(\text{FEC} + 1)$. Statistical inferences were made on transformed data and untransformed least squares (LS) means were presented. Lambs were dewormed

if anemic (2004, 2005: $\text{PCV} < 19\%$; 2006, 2007: $\text{FAMACHA score} > 2$) and data removed within 30 days after deworming, but may have been included 31 or more days later.

3. Results

There tended ($P < 0.10$) to be sire differences for FEC at 90 and 120 days of age (Figs. 2A, C, 3A and C), but not 150 days of age (Figs. 2E and 3E). Sire differences were detected for PCV by 150 days of age in 2004 ($P < 0.04$; Fig. 2F) and in 2006 and 2007 were significant at all time points examined (90 days, $P < 0.02$; Fig. 3B; 120 and 150 days, $P < 0.001$; Fig. 3D and F). Sire differences were detected for FAMACHA scores at all time points in 2006 and 2007 (90 days, $P < 0.05$; Fig. 4A; 120 days, $P < 0.02$; Fig. 4B; 150 days, $P < 0.003$; Fig. 4C). There was a greater frequency of FAMACHA scores of 1 and 2 at 120 days of age for Ram D than Ram C in both years ($P < 0.03$) and more anemic scores (3 and 4) in 2006 than 2007 ($P < 0.001$; Fig. 5). There were more offspring from Ram D that did not require deworming compared with those from Ram C ($P < 0.001$; Fig. 6).

Differences in PCV between years 2004 and 2005 ($P < 0.001$; Fig. 2B and D) and 2006 and 2007 ($P < 0.001$; Fig. 3D and F) were detected. Differences in FEC between years 2006 and 2007 at 120 and 150 days of age were detected ($P < 0.001$; Fig. 3C and E), but FEC were similar in 2004 and 2005. There was more frequent deworming required in 2006 than 2007 (Fig. 6). The effects of parasites were greater in female than male lambs in 2004 and 2005 with lower PCV and higher FEC at 90 and 150 days of age ($P < 0.001$), but in 2006 and 2007 PCV and FEC were similar between genders except for a higher PCV at 120 days of age for female lambs. Total rainfall during the 60–150 days of age period for 2004, 2005, 2006, and 2007 was 181.4, 244.9, 289.5, and 216.8 mm, respectively (Fig. 1).

Body weight was greater at birth ($4.2 > 3.7 \pm 0.08$ kg; $P < 0.001$) and 90 days of age ($23.6 > 22.2 \pm 0.4$ kg; $P < 0.02$) in lambs sired by Ram B compared with those sired by Ram A, but not at 60 (21.2 vs. 20.3 ± 0.4 kg) or 120 days of age (27.5 vs. 26.6 ± 0.4 kg). Lambs were heavier at 60 ($22.2 > 19.3 \pm 0.4$ kg), 90 ($26.6 > 19.2 \pm 0.4$ kg), and 120 days of age ($33.2 > 20.9 \pm 0.6$ kg) in 2005 compared with 2004 ($P < 0.001$), but birth weights were similar. Body weight was greater at birth ($4.5 > 4.2 \pm 0.11$ kg; $P < 0.04$) and 60 days of age ($23.6 > 22.3 \pm 0.4$ kg; $P < 0.03$) for offspring sired by Ram C compared with those sired by Ram D, but body

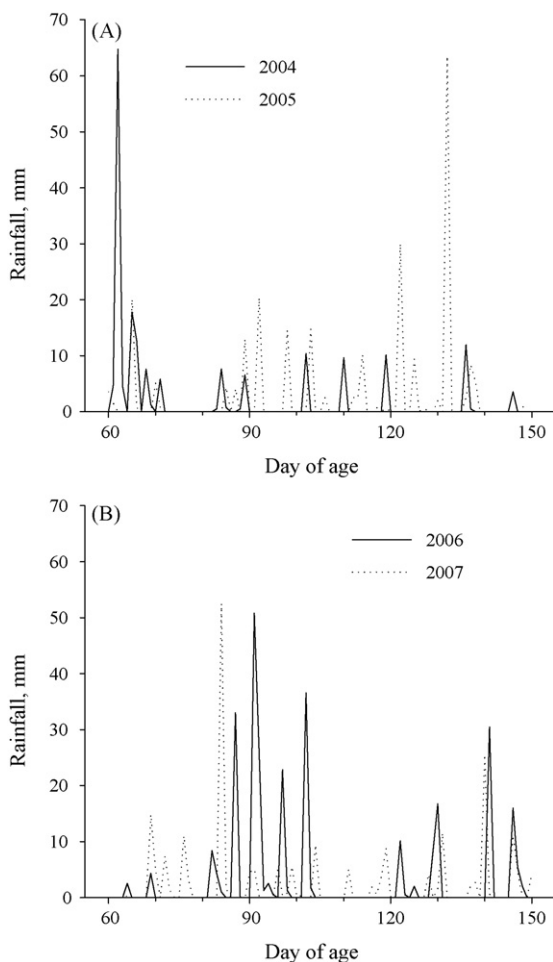


Fig. 1. Daily rainfall (mm) recorded at the USDA, ARS Dale Bumpers Small Farms Research Station (complementary of D. Burner) between 1 June and 30 September 2004, 1 April and 30 June 2005 (A), 1 April and 30 June 2006 and 2007 (B), which corresponded to 60–150 days of age for lambs each year.

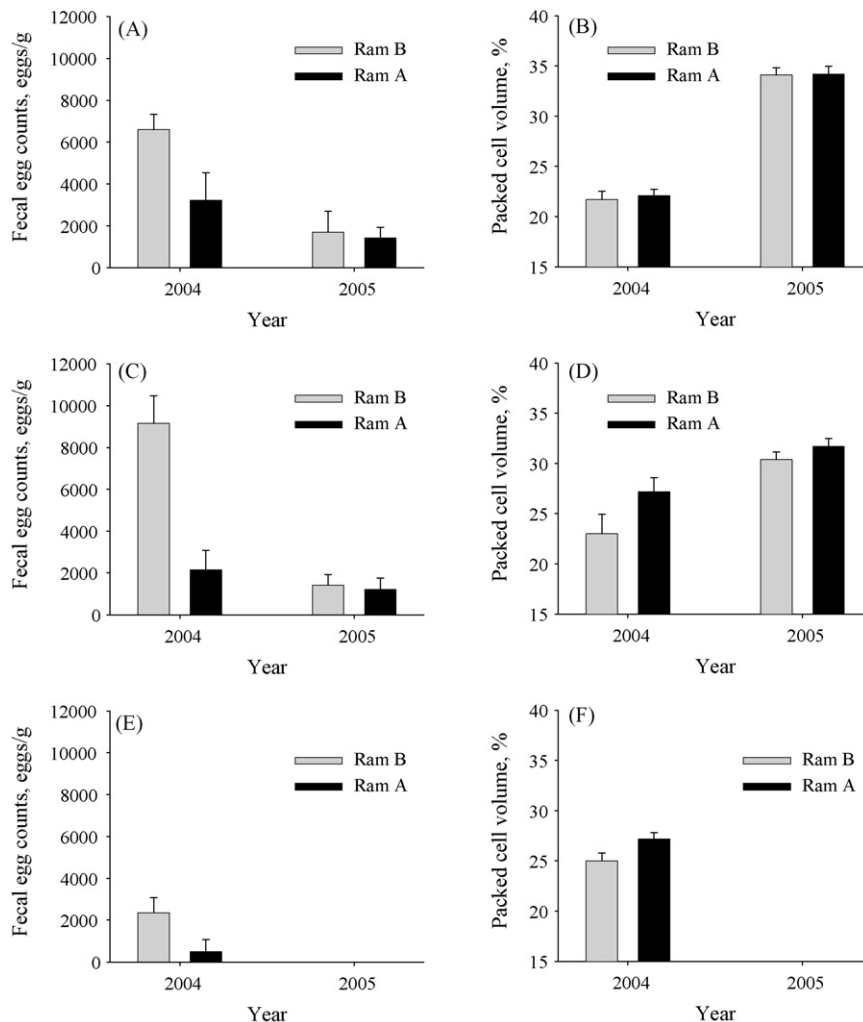


Fig. 2. Least squares means and standard errors of fecal egg counts (A, C, E) and packed cell volume (B, D, F) of lambs sired by Ram A or Ram B in 2004 and 2005 at 90 (A, B), 120 (C, D), and 150 (E, F) days of age. Lambs were weaned at approximately 90 days of age. Fecal samples were not collected in 2005 at 150 days of age.

weight was similar between sire groups at 90 (30.8 vs. 29.9 ± 0.5 kg) and 120 days of age (32.6 vs. 32.8 ± 0.6 kg). Body weights at all time points were similar between 2006 and 2007.

4. Discussion

It was reported earlier that Katahdin lambs on this farm remained susceptible to GIN parasites, while mature ewes were resistant (Burke and Miller, 2004).

When the FAMACHA system was implemented in the Katahdin flock in 2006 in the current study it became a useful tool in identification of sires with parasite resistance or resilience. Their offspring required a reduced number of anthelmintic treatments than offspring from more susceptible sires. Resistance

is defined as the ability of the host to limit FEC during a heavy challenge of GIN (Bisset et al., 2001). Resilience is defined as the ability of the host to resist anemia during a heavy challenge and will result in fewer number of animals being identified for deworming using the FAMACHA system. In the current study, in all years, use of PCV or FAMACHA to identify sires that had fewer offspring dewormed (resilience) was more reliable than use of FEC. This may be an indication that this population of Katahdin sheep is more resilient than resistant.

In 2004 and 2005, because differences in PCV between sire groups was less apparent, if the FAMACHA system had been employed, scores may have been similar between groups. Thus, sire differences may not have been detected. FEC tended to be

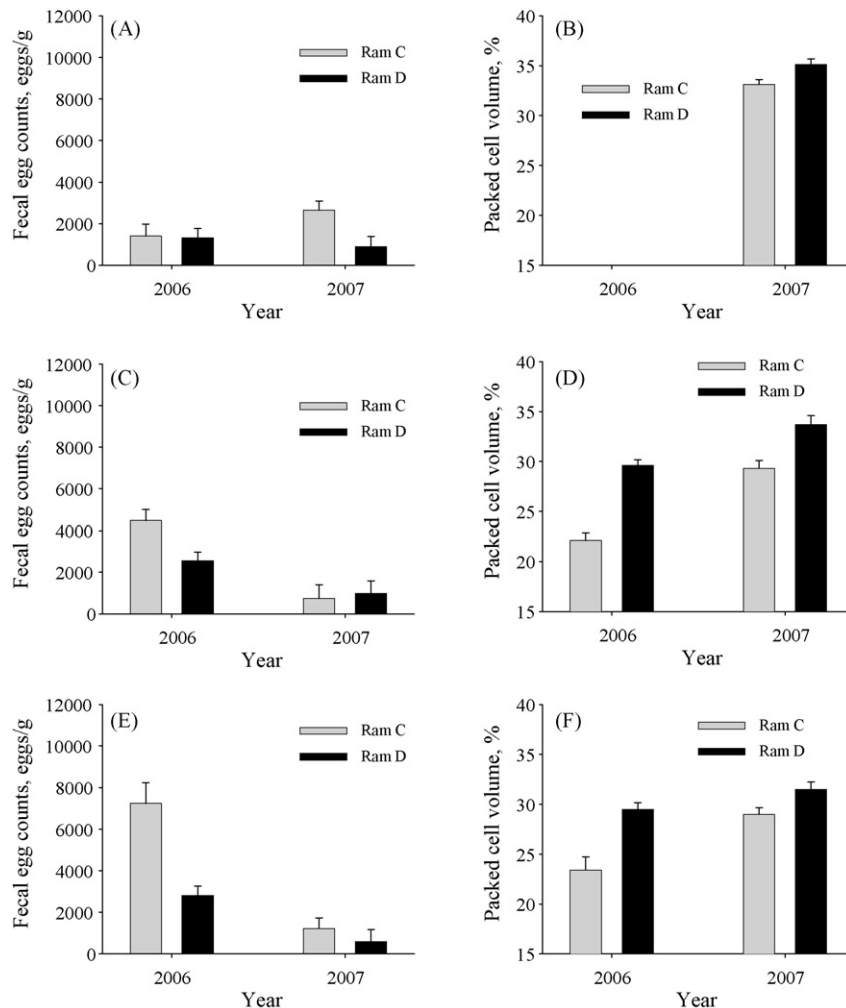


Fig. 3. Least squares means and standard errors of fecal egg counts (A, C, E) and packed cell volume (B, D, F) of lambs sired by Ram C or Ram D in 2006 and 2007 at 90 (A, B), 120 (C, D), and 150 (E, F) days of age. Lambs were weaned at approximately 90 days of age. Blood samples were not collected in 2006 at 90 days of age.

different between groups and selection of sire using this criterion may have resulted in more resistant lambs. Selection of Ram D occurred from the 2004 group (Ram A) of lambs because he had never required deworming and his FEC was 2650 eggs/g at 90 days of age and declined to 150 eggs/g or less thereafter (measured up to 128 days of age; unpublished data).

Greater resilience in lambs from Ram D led to 60% and 24% fewer deworming treatments by 150 days of age in 2006 and 2007, respectively, compared with offspring from Ram C. By selectively treating lambs with FAMACHA scores of 3 and greater, 30% of non-anemic lambs were dewormed in an on-farm study; but, when only treating scores of 4 and 5, only 6% would have been treated (Burke et al., 2007). Therefore, there were several lambs unnecessarily dewormed in the

current study. The model for selecting resilient sires would have been more sensitive had treatment occurred with the more liberal criteria. When FEC are similar between groups of lambs, but PCV is different, erythropoiesis in resilient animals may increase, as was observed in calves resistant to trypanosomes (Andrianarivo et al., 1996).

Differences between sire groups were greater when the parasite challenge was higher. More rainfall leading to more favorable conditions for infective larvae on pasture before weaning in 2004 likely led to an increased FEC and decreased PCV at 90 days of age compared with 2005. In addition, because of the poorer forage quality associated with the later lambing season in 2004, lambs may have remained more challenged by parasites during their first 4 months of age and beyond.

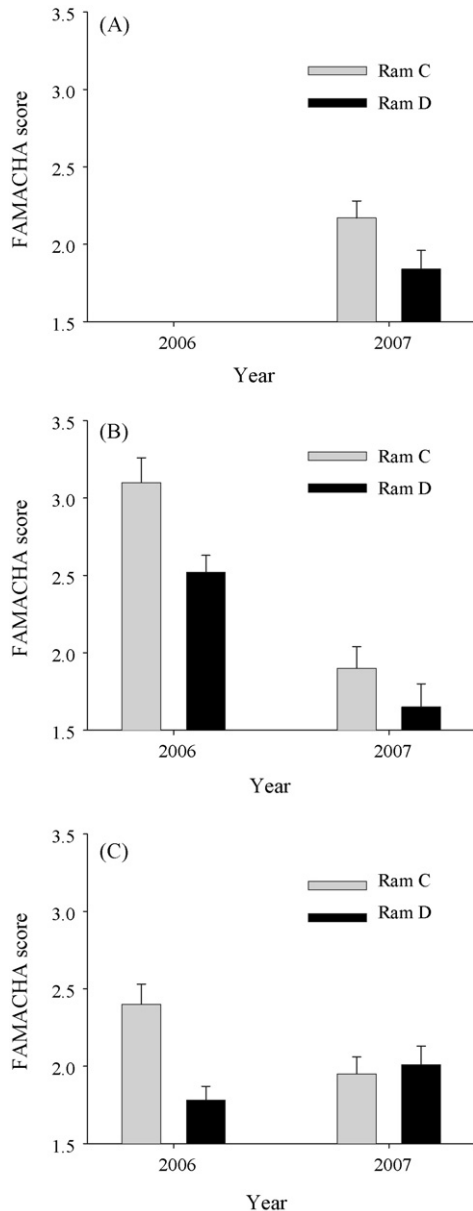


Fig. 4. Least squares means and standard errors of FAMACHA scores (1 = healthy and 5 = severely anemic) of lambs sired by Ram C or Ram D in 2006 and 2007 at 90 (A), 120 (B), and 150 (C) days of age. Lambs were weaned at approximately 90 days of age. FAMACHA scores were not determined in 2006 at 90 days of age.

Lambs gained little weight between 60 and 120 days of age in 2004, which could have been attributed to heat stress, poor forage quality, and parasitism. Similarly, greater rainfall around the time of weaning in 2006 likely led to increased FEC at 120 and 150 days of age compared with 2007. During periods of adequate rainfall and moisture conditions optimal for develop-

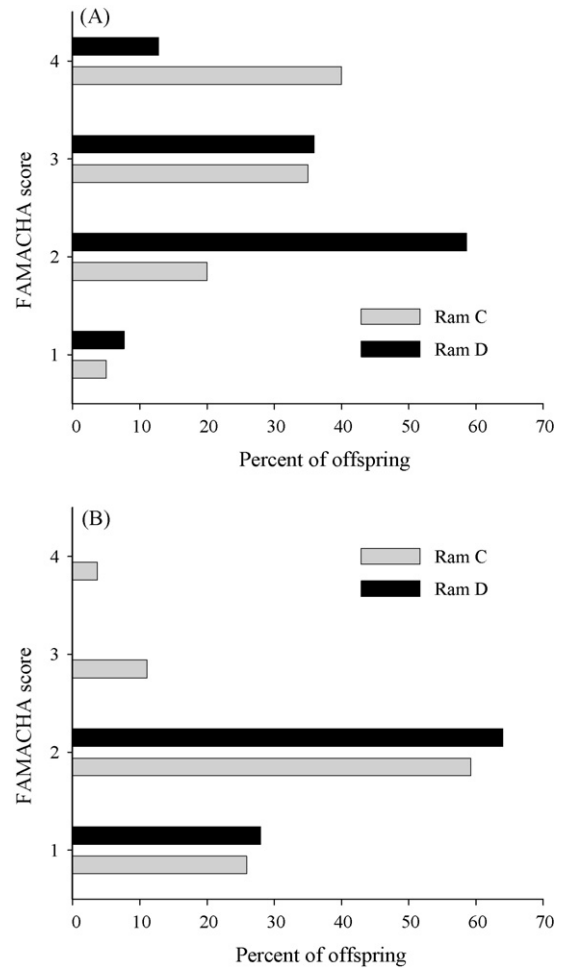


Fig. 5. Percentage of offspring from each sire (Ram C or Ram D) for each FAMACHA score (no scores of 5 were recorded) in 2006 (A) and 2007 (B) at 120 days of age. Lambs were weaned at approximately 90 days of age.

ment of GIN on pasture, the differences in LS means (FEC, PCV, and FAMACHA) between the two sire groups became greater. Also, an increase in PCV in 2007 compared with 2006 could have been attributed to an increased plane of nutrition as forage availability appeared to be greater because of more and steadier rainfall and a wetter spring.

The only unbiased estimate of GIN infection between the two sire groups for all 4 years was the 90-day of age time point. That is because lambs were dewormed as they became or showed signs of anemia (low PCV or high FAMACHA score) after 90 days of age. Lambs that were dewormed were removed from the estimate for LS means within 30 days, and GIN infection was reduced from anthelmintic treatment (2004, 2005) or use of copper oxide wire particles (2006, 2007). Because these

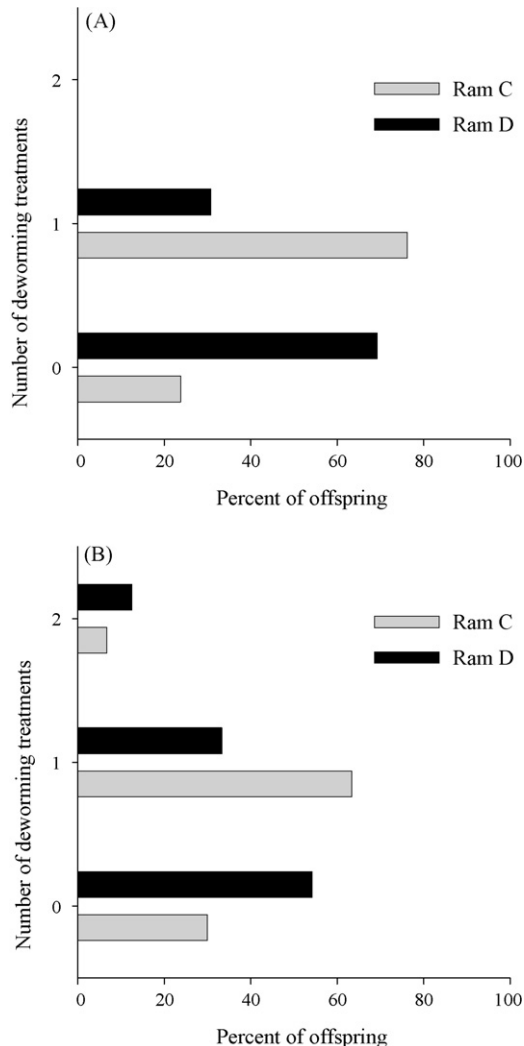


Fig. 6. Number of deworming treatments required for offspring from each sire (Ram C or Ram D) in 2006 (A) and 2007 (B) by 120 days of age. Lambs were weaned at approximately 90 days of age. Lambs were examined every 7 days after weaning and treated with 0.5 g copper oxide wire particles if FAMACHA scores were 3 or greater.

Katahdin lambs were resilient to GIN infection (high FEC without reduction in PCV), many could have remained untreated without detriment and a better estimate gained between sires, but a proportion left untreated could have died. Regardless of the bias or some unnecessary deworming of lambs, results of estimates of parasitism were similar among time points.

Selection for resilience could leave unselected animals more susceptible to GIN if pastures are not managed to reduce build up of larvae. Because FEC of many of the lambs in 2006 and 2007 was high without a low PCV, these lambs would still be contributing to

pasture infectivity. However, there is a significant positive correlation between FAMACHA and FEC (Kaplan et al., 2004; Burke et al., 2007). When using the FAMACHA system to select for resilient sires or lambs, producers should be aware that initially, lambs that lack resistance may be more susceptible to GIN because of greater pasture infectivity. Over time, as susceptible animals with higher FEC are culled, pasture infectivity should decrease and overall GIN infection in flocks should lessen. Through careful record keeping, producers should be able to apply the FAMACHA system and identify not only resilient and possibly resistant lambs, but resilient/resistant sires.

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